Atmospheric Correction Over the Indian Subcontinent Using Fast Radiative Transfer Models and Neural Networks

AVIRIS-NG SCIENCE TEAM MEETING
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Problems with Current Approach

- Limits atmospheric information that can be recovered

- Less accurate for certain observing conditions
  - High water vapor, extreme viewing angles, high aerosol loading, non-Lambertian surfaces

- Orbital missions will not have flexibility to wait for optimal weather conditions
  - Tropical and subtropical environments often show extreme conditions that challenge existing approaches

Fast “Full Physics” RT

- Two-stream exact-single-scattering (2S-ESS) model (Spurr and Natraj, 2011)
  - 2S computes multiple scattering field using two-stream approximation
  - ESS computes single scattering field accurately, including atmospheric sphericity effects

- Incorporates state-of-the-art representations
  - Delta-M scaling
  - Nakajima-Tanaka (N-T) correction
  - Surface BRDF
  - Analytic Jacobians

- For calculations in a 20-layer atmosphere with 100 spectral points, 2S-ESS is ~800 times faster compared to DISORT with eight discrete ordinates in the half-space

- Accurate to within 0.1% of an “exact” RT model, but with computational speed comparable to two-stream models

2S-ESS Model Benefits

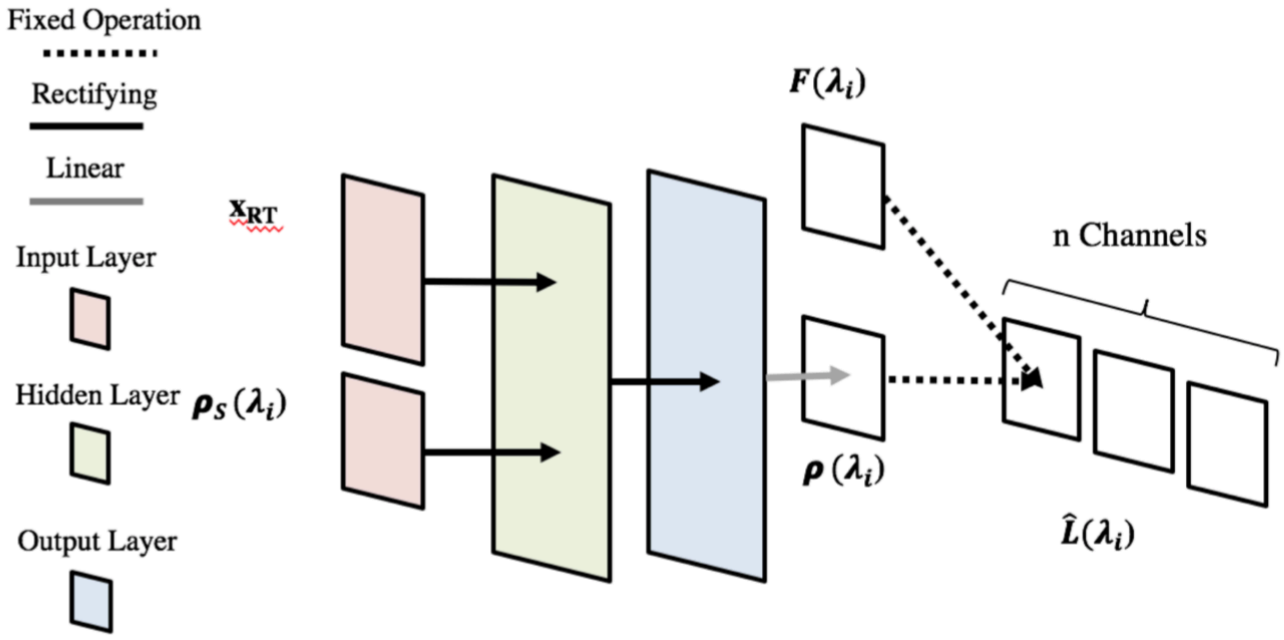
- Can be used for scenarios with heavy aerosol loading
- Systematic errors due to cirrus can be accounted for
- Opens up avenues for simultaneous retrievals of surface, aerosols, water vapor and trace gases (e.g. NO_2, CH_4, CO_2)

Emulation of RTM Ouput

- Nonparametric regression model
- More accurate alternative to lookup tables
- Permits very high dimensional state vectors
- Neural network models should enable many-frames-per-second retrievals
- Orders of magnitude speed improvement over MODTRAN-based model with negligible accuracy penalty

Neural Network Schematic

1. Wide, shallow architectures – perform better than deep architectures
2. Monochromatic subnetworks – model each wavelength independently for superior generalizability and training
3. Physical decompositions – simplify the problem using physics insight

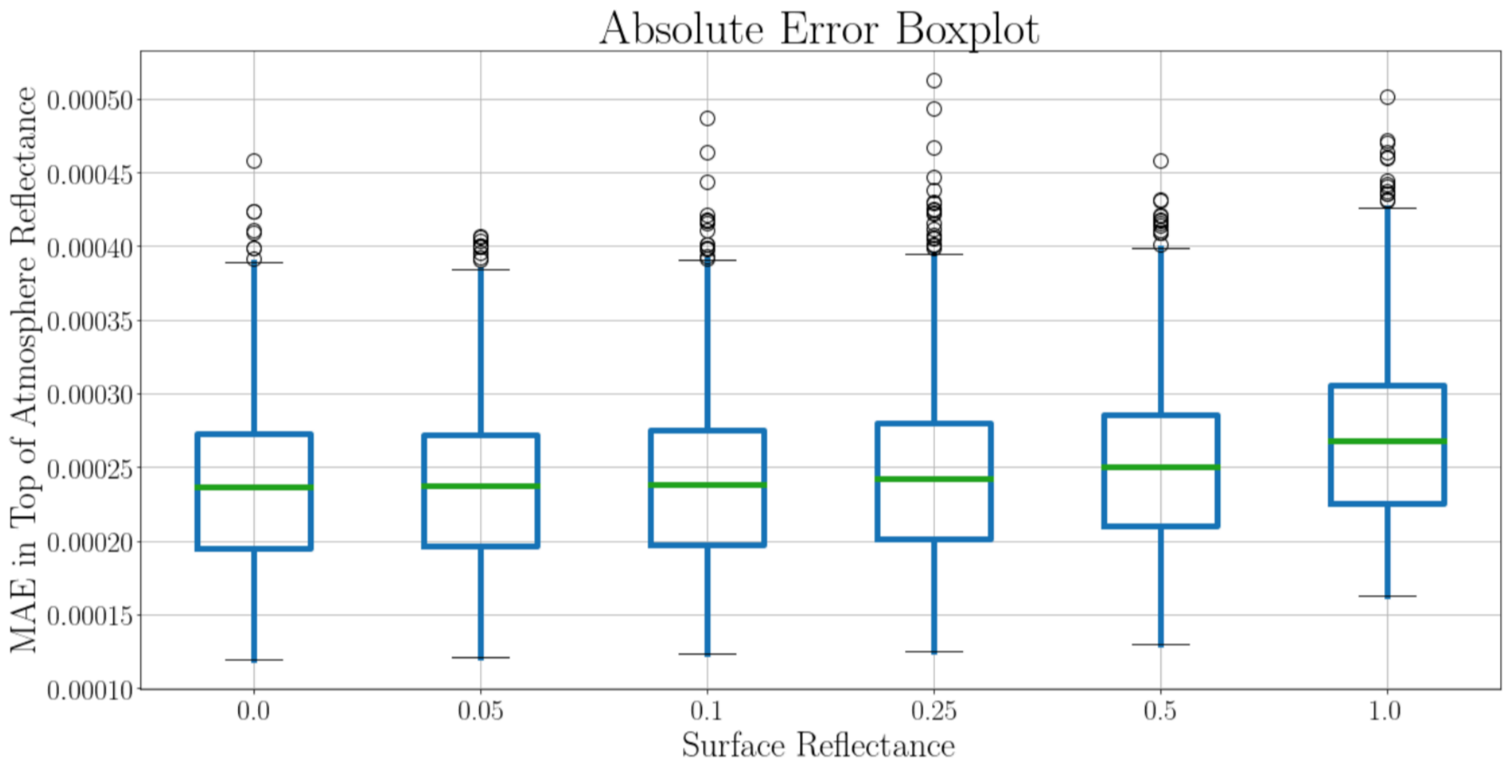


Training Set

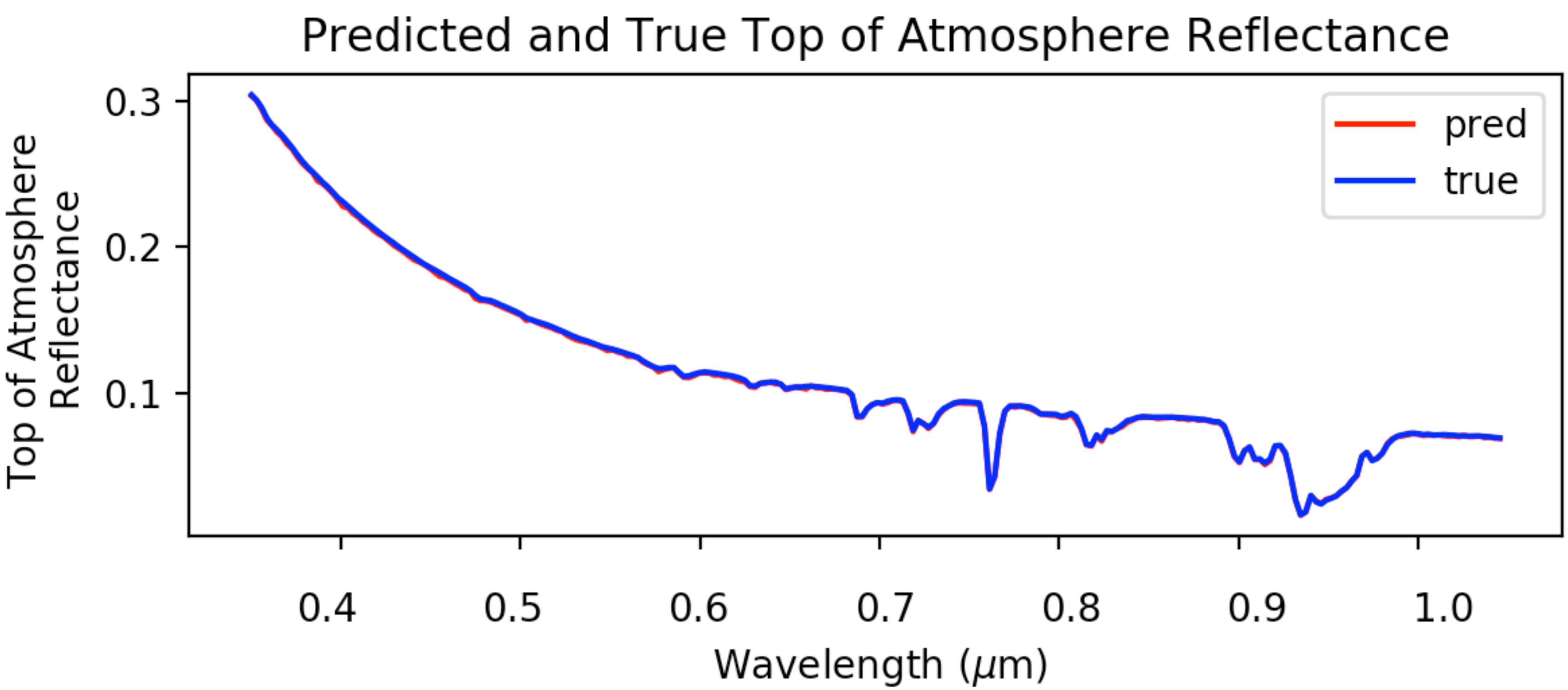
Parameter	Sample Points
ϕ_r, azimuth between observer and sun	0.0, 0.393, 0.785, 1.178, 1.571, 1.963, 2.356, 2.748, 3.141
$\cos\theta_v$, cosine of the observer zenith angle	0.94, 0.95, 0.96, 0.97, 0.98, 0.99, 1.0
τ, atmospheric aerosol optical depth at 550 nm	0.05, 0.1, 0.2, 0.3
H_2O (g cm^{-2}), atmospheric water vapor content of the column	1.0, 1.5, 2.0, 2.5

Results

- 0.001 Absolute error
- 3 milliseconds runtime (>5 minutes for full RTM)



Worst Case Prediction



Future Work

- Improving aerosol retrievals by using better priors (Kindel and Massie)
- Improving surface retrievals by using BRDFs
- Testing model using full AVIRIS-NG India dataset
- Validation using in situ measurements

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